

XIV. *Experiments on Water obtained from the melted Ice of Sea-Water, to ascertain whether it be fresh or not; and to determine its specific Gravity with respect to other Water. Also experiments to find the Degree of Cold in which Sea-Water begins to freeze.* By Mr. Edward Nairne. Addressed to Sir John Pringle, Bart. P. R. S.

TO SIR JOHN PRINGLE, BART. P. R. S.

S I R,

Hampstead,
Feb. 1, 1776.

R. Feb. 1, 1776. IT having been suggested, in a conversation at which I was present, that the ice of sea-water is not fresh; and that if the ice found near the poles be really so, it must probably be the ice of fresh water discharged into the sea from large rivers in those parts: I thought the present cold weather afforded an opportunity too favourable to be lost, of ascertaining by experiment, whether the water obtained from the melted ice of sea-water be free from the taste of salt or not; of comparing its gravity with that of the sea-water, &c.; and of finding the degree of cold in which the latter begins to freeze: and I beg leave to lay before you an account of my researches in these matters, and of the methods I followed in making them. If you, SIR, should think them worthy of notice, and would communicate them to the learned body over which you preside, you would confer an honour on, &c.

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THE sea-water used in the following experiments was furnished by Mr. OWEN, who keeps the Mineral Water Warehouse, at Temple Bar; who assured me, that it was taken up off the North Foreland.

On the 27th of January, 1766, at ten o'clock in the evening, I filled a jar $3\frac{1}{4}$ inches in diameter and $6\frac{1}{2}$ inches deep, with sea-water, and exposed it to the open air, the thermometer standing at 15° . At noon the next day, on taking it in, I found it frozen very hard, except a very little at the bottom, which remained quite fluid: I now set it by a stove in a heat of 56° to thaw. The ice when taken in from the open air was one quarter of an inch above the edge of the jar. When the jar had continued in the degree of heat abovementioned during eight hours, I took out the ice, which was then $3\frac{1}{2}$ inches long and two inches in diameter; about two-thirds of the water appeared to remain. In order to clear the ice from any brine that might adhere to it, I washed it in a pail of pump water, in which it was suffered to remain about a quarter of an hour, and then set it in a sieve to drain off the water in which it had been washed.

On the 29th of January, 1776, I set the beforementioned ice in a basin in a heat of about 46° , in which it continued nine hours before the whole was dissolved. The bulb of a thermometer rested on the ice during the time of the solution, and continued without variation at 32° . The water thus obtained was, to my palate, perfectly free from any taste of salt.

In order to ascertain the comparative gravity of this water, I filled a bottle with it to a certain mark in its neck, which was very narrow, and weighed the bottle so filled very carefully. I weighed the same bottle, filled to the same mark in its neck with sea-water and other waters successively, which were all brought to the same degree of heat by a thermometer. The results were as follow; *videlicet*,

	Grains.
Water obtained from the melted ice of the sea water,	} 1614
Distilled rain water,	1612
Water taken out of a water tub, being a mixture of rain and snow water,	} 1615
The sea water,	1653
The <i>residuum</i> of the sea water from which the ice before mentioned had been taken,	} 1659

To find the degree of cold in which sea water begins to freeze, I made the following experiments.

I exposed to the open air a decanter filled with the sea water, in which a thermometer was suspended, the bulb of which reached to the middle of the widest part of the decanter; a jelly glass filled with the same sea-water, in which also a thermometer was put, resting on the bottom, was placed in the same exposure. The result will be seen in the following table:

January 29, 1776.

Vessel.	Time.	Immersed Therm.	Therm. in the open Air.	Effects, &c.
Decanter, Jelly glafs,	11 30 A.M.		19	
Decanter, Jelly glafs,	12 0	33 25 to 28.5	19	A number of beautiful feathered crystals appeared in the jelly glafs; they began to shoot from the top, which was covered with ice, toward the bottom; when they reached it, the thermometer rose immediately from 25 to 28.5.
Decanter, Jelly glafs,	12 15	31 28.5	19	Ice began to form in the decanter, though hardly perceptible at the edge of the water.
Decanter, Jelly glafs,	12 20	30 28.5		
Decanter, Jelly glafs,	12 30	29 28.5	19	Crystals of a laminated appearance began to shoot downwards obliquely from the ice at the surface, which at the edge of the water was barely two-tenths of an inch thick; no appearance of ice in the middle of the surface.
Decanter,	1 oP.M.	27.5	19	Crystals began to shoot round the neck of the decanter close to the glafs.
Decanter,	1 15	28.5	19	The inside became covered with finely feathered crystals, which made it impossible to observe the height of the thermometer, without raising it till the quick-filver in the tube appeared above the ice.
Decanter,	4 0	28.5	19	

January

January 29, at eight o'clock in the evening, I exposed to the open air two similar jars, each $5\frac{1}{2}$ inches deep and $1\frac{7}{10}$ inch in diameter; one of which I shall, for the sake of distinction, call A; the other, B. A was filled with the sea water; B with water taken out of a water tub, which was a mixture of rain and snow water. In A two thermometers were placed; one rested on the bottom; the upper part of the ball of the other was a quarter of an inch only below the surface of the water; one thermometer was also placed in B, resting on the bottom. The following table shews the result.

Vessel.	Time.	Therm. at the Top.	Therm. at the Bot- tom.	Therm. in the open Air.	
A	8	60	60	19.5	
B	8 o.P.M.		60		
A	8 15	40	33		
B			38		
A	8 20	35	29.5		
B			37.5		The surface of the water in B covered with ice.
A	8 25	31	26.5		
B			34		Surface as before.
A	8 30	29	25		No appearance of ice.
B			32		The ice on the surface increased.
A	8 32	28.5	24.5		Ice began to appear on the surface.
B			32		Quite frozen.
A	8 36	28.2	28.5		Crystals over every part of the glass.
B			32	20	As before.

N. B. During the time in which these observations were made, the thermometer in the open air rose half of a division.

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The following table shews the result of some further observations on the effects of cold on the sea-water in the jar A of the last table, which had been thawed in order to be now exposed again to the open air. The thermometers in the jar continued in the same situation as before.

January 30, 1776, A. M.

Time.	Therm. at the Top.	Therm. at the Bot- tom.	Therm. in the open Air.	Effects, &c.
10 32	34.5	35.5	16.5	The water fluid.
10 39	29	32		Ice began to be formed about the glass at the edge of the water.
10 42	28.5	30.5		Still continued to have ice only about the edge of the water.
10 48	28	28		The surface of the water rendered stagnant by the ice.
11 1	27	24.5	18.5	The crystals had almost reached the bottom.
11 1½ }	27 +	28.5		During the half minute employed in this observation, the crystals reached the bottom of the jar; the lower thermometer rose almost instantaneously from 24.5 to 28.5, and was immediately rendered obscure by the ice.
11 45	26.5	28.5	19	The jar was taken in from the open air, and the lower thermometer lifted out of the ice to a sufficient height for the observation.

From these observations it seems that the freezing point of sea-water should be fixed in FAHRENHEIT's scale at 28.5.

As the water, when it began to freeze in two experiments, exhibited phenomena different from any I had observed before, it may not be improper to subjoin an account of them.

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At fourteen minutes after eight in the morning of January 31, I put the jar *b* of the second table, containing the same water; *viz.* a mixture of rain and snow water, in a window, having the evening before placed a second thermometer in it, the bulb of which was just below the surface of the water. This as well as the thermometer at the bottom stood at 27.5, and the water was perfectly fluid: the thermometer placed near the jar within the window was at 23.5. At twenty-seven minutes after eight it began to freeze at the bottom of the jar, the thermometers at the top and bottom standing alike at 27. The instant the crystals began to encompass the ball of the thermometer below, which they very soon did after it began to freeze, the quicksilver rose in it to 32°, the upper one continuing at 27°. The crystals continued to shoot upward, and in less than half a minute reached the bulb of the thermometer at the surface, which immediately rose to 32°.

At ten minutes before six in the evening of the same day, I put the jar *A* of the second table into the open air, its contents the same; *viz.* sea water. The thermometers in it were likewise the same, not having been moved; they both stood at 34°; that in the open air at 19.5. At six o'clock the thermometer above was at 31°, that below at 28.25. At this time I discovered some ice on the surface of the water; but as it was by candle-light, I could not discern its first appearance. At ten minutes after six, the thermometer above was at 29°; that below at 26.5. At fifteen minutes after six, the upper thermometer at

28.5; that below at 25°. At seventeen minutes after six, both the thermometers stood at 28.5, crystals having risen from the bottom covered the ball of that below, on which it rose instantly from 25° to 28.5. The thermometer in the open air continued as at first; *viz.* at 19.5.

The scale of all the thermometers used in these experiments was FAHRENHEIT's. I have sent herewith specimens of the water; *viz.* of the sea-water; of the water procured from its melted ice; and of the *residuum* of the sea-water from which the ice was taken.